

NASA TECHNICAL TRANSLATION

NASA TT F-17086

FUTURE SPACE FLIGHT PROGRAM OF THE USA -- PROJECTION
TO THE TURN OF THE CENTURY

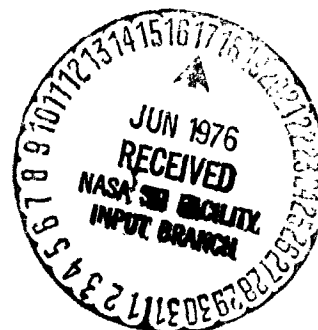
H. W. Koehler

Translation of "Zukünftiges Raumfahrtprogramm der USA -- Vorausschau
bis zur Jahrhundertwende," Preprint to be submitted for
publication 1976, 18 pp.

(NASA-TT-F-17086) FUTURE SPACE FLIGHT
PROGRAM OF THE USA: PROJECTION TO THE TURN
OF THE CENTURY (Kanner (Leo) Associates)
20 p HC \$3.50 CSCL 22A

N76-26231

Unclas
G3/12 28338



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C.

MAY 1976

STANDARD TITLE PAGE

1. Report No. NASA TT F-17086	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle FUTURE SPACE FLIGHT PROGRAM OF THE USA PROJECTION TO THE TURN OF THE CENTURY		5. Report Date May 1976	6. Performing Organization Code
7. Author(s) H. W. Koehler		8. Performing Organization Report No.	10. Work Unit No.
9. Performing Organization Name and Address Leo Kanner Associates Redwood City, California 94063		11. Contract or Grant No. NASW-2790	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration, Washington D.C. 20546		Translation	
14. Sponsoring Agency Code			
15. Supplementary Notes Translation of "Zukünftiges Raumfahrtprogramm der USA -- Vorausschau bis zur Jahrhundertwende," Preprint to be submitted for publication 1976, 18 pp.			
16. Abstract This article describes the outlook for a civilian space program over the next 25 years. Within the next 10 years or so much of the activity in space will be limited to near-Earth geocentric orbits, and solar system exploration will develop well beyond the missions defined at the present time. An essential element of the US space program of the future is the development of the Space Shuttle. During the 1990's small space stations for scientific and commercial purposes might be established. More ambitious concepts like a manned lunar base, a manned Mars mission or settlement, huge satellite solar power stations, and the evolutionary development of an orbiting colony will not be undertaken before the turn of the century. Because of the high costs involved, the potential economic and social benefits of any future space programs in the USA would have to be considered quite clearly.			
17. Key Words (Selected by Author(s))		18. Distribution Statement Unclassified-Unlimited	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages	22. Price

Future Space Flight Program of the USA -- Projection to the Turn of the Century

H. W. Koehler

The high point of the American space program of the current /1* year will be the two soft landings of the Viking capsules on the planet Mars in the first week of July and the second week of September respectively [1]. These events are being awaited with considerable anticipation by both the public and the scientific community. At the same time, other agencies within the civilian National Aeronautics and Space Administration (NASA) are already at work selecting and defining programs for the next 2 decades. This article will review the status of these plans.

Important Programs Through 1980

The program organization for the next 3 years can be considered fixed, and will at most be delayed in one case or another by budget cutbacks. The NASA budget presented at the beginning of 1976 for the fiscal year 1977 has been increased by almost 4% over the previous year (Table 1), but the real budget total has in fact decreased due to inflation. Consequences are, for example, a one-year delay in the beginning of construction of the third upper stage (Orbiter) of the 2-stage Space Shuttle, a (further) postponement of the starting date of the Space Telescope ST and a delay in a new Jupiter-Pioneer planet-research program (PJOP).

Under the pressure of the tight budget of the past year, NASA has made a compromise between scientific importance, anticipated results, and economy in planning its program: for instance, only two of the 16-19 launches planned for 1976

Numbers in the margin indicate pagination in the foreign text.

are being financed entirely by NASA itself; in two other cases, the projects are cooperative programs with foreign countries. The cost of the remaining 12-15 launches are being borne completely by other organizations and countries. This trend will continue in the coming year: in 1977, NASA will launch 18-23 satellites and capsules, but only 6 of these will be NASA's. Most of 12 these are commissioned launches of scientific and particularly of commercial-applications satellites (communication, navigation, meteorology). The most important NASA projects in 1977 are the launching and operation of the third Landsat earth reconnaissance satellite, the high-energy astronomical observatory HEAO, and the two Mariner capsules for flybys of the planets Jupiter and Saturn.

The Mariner Jupiter Saturn program begins with the launching of two 750-kg probes between the middle of August and the middle of September 1977. They will then reach the planet Jupiter on April 2 and May 15, 1979 and will reach Saturn on January 16 and April 21 1981. Measurements with the 11 scientific instruments on board each of the probes are planned for the interplanetary space between Jupiter and Saturn; the planets themselves are to be observed and photographed over a number of weeks. Moreover, at least two moons of each of the two planets are to be studied in detail and 6 others characterized geologically.

The planet Venus will be the destination of 2 automatic space laboratories of the Pioneer type in December 1978. These launchings are planned for May and August 1978 [2]. One large and three smaller identical probes together with the probe carrier will penetrate the atmosphere of Venus, while the second space vehicle will be inserted into an elliptical orbit around the planet.

Although NASA will not undertake any new space projects in 1976, 3 new projects -- in addition to current projects -- will be begun in the space-flight sector in the following year:

Solar Maximum Mission (SMM): this is a probe to study sunspots, flares, and other solar events during the next period of maximum solar activity (1979-1980).

Magsat: a third applications-research satellite to obtain data for global measurement of the earth's magnetic field. This information will also be used to explore for deposits of natural resources such as oil and minerals.

Thematic Mapper: a new instrument to make the discovery of resources from orbit and the monitoring of their depletion simpler and more reliable.

As for manned space flight, no further missions are planned /3 through 1980. In this period, the single goal is to develop and test the Space Shuttle with a minimum of cost overruns and delays. For 1977, 1.288 billion dollars have been allocated for the project; in 1975, it was only 797.5 million dollars. The Space Shuttle test program envisages 3 experimental flights in each of the 2 years 1979 and 1980. According to the present timetable, the first five operational shuttle missions are to take place before the end of 1980.

Hardware work on the US Space Shuttle is being accompanied (in Europe and West Germany as well) by efforts to define suitable experiments for the European orbital laboratory Space-lab, which is to be lifted into earth orbit by the Space Shuttle sometime after 1980. By the beginning of 1976, NASA has already specified about 200 suitable space experiments in 11 scientific disciplines, and had urged interested scientists in the USA itself and in all nations not belonging to the ESA to submit concrete proposals for experiments on the first Space-lab mission (the European space organization ESA published a similar call to the scientists of its 11 member countries. The final selection of the experiments from the proposals received will eventually be made jointly by NASA and ESA). Spacelab 1 is scheduled to be launched on July 15, 1980 from NASA's Kennedy Space Center.

Planning for 1980-2000

In order to formulate and evaluate needs and scientific objectives for future space projects through the year 2000, NASA administrator Dr. James C. Fletcher, in the Summer of 1974, advocated the appointment of a 20-member committee of prominent space scientists and engineers to render advice on future activities in the course of a 1-year "Outlook for Space" study. The results of these efforts appeared in January 1976 [3]. At the same time, another group of specialists was dealing with questions of the civilian role of the future American space program during the next 25 years [4].

While some members of the study group believed that square-kilometer geostationary satellites to convert solar radiation into electrical power would be launched before the end of the century, others favored the idea of roomy space stations continuously occupied by hundreds of workers, engineers, and scientists. A number of other participants gave preference to a manned Mars flight, while still others suggested the continuation and expansion of proven satellite concepts to permit more reliable weather prediction, storm warnings, lower-cost news and information transmission, etc. /4

Table 2 shows the proposals of the "Outlook for Space" study in compressed form. Subdivided into two main groups with a total of 12 topic areas and 61 subgroups or questions, the table does not contain any fundamentally new concepts, but only lists those possibilities which promise the maximum progress and benefit for mankind. Of course, not all of the 61 items can be accomplished, since problems, opportunities, financial resources, and priorities will always change over the course of years. Nevertheless, the opinion of the study group is that all 61 proposals should be examined seriously with a view to subsequent implementation. Three particularly promising areas were selected as possible permanent ingredients of a future space program:

- Improved ways to study the earth's climate, in order to permit prediction of short-range and long-range climatic changes;
- Expansion of scientific knowledge on the creation and development of the solar system;
- Possibilities for manned orbital missions.

These three projects will now be discussed in more detail.

Climatic Research

Climate on the earth appears to undergo cyclic variations, with periods of decades, centuries, and even longer times. Parts of our present economic system are based on relatively constant climate, and would be jeopardized if this climate were to change over a few decades. A drop in the average annual temperature by just 1° C would, for the USA for example, cause an annual financial loss of 1 billion dollars in wheat and rice harvests, 2.2 billion dollars in forest products and 1.4 billion dollars in products of the sea, entirely aside from extra expenses for health. Overall economic losses due to meteorological phenomena have been estimated at 12 billion dollars annually, of which about 5 billion are avoidable. Better weather prediction 30 days in advance might already reduce these losses by 500 million dollars a year. /5

Therefore, further information must be acquired regarding the origins of weather, in order to predict climatic changes and trends, regardless of whether they are due to natural or human causes (air and water pollution).

Such a research project will require large numbers of measurements using aircraft, balloons, and underwater probes, but can hardly have any future success without the use of appropriate satellites. A step in the right direction is the upcoming international global atmospheric research program (GARP), in which the US, the USSR, and Japan, together with the ESA, will be represented with their own satellites. This project to observe the condition and motion of the entire atmosphere of the earth will begin at the end of 1978, will last about a year,

and is being prepared and coordinated by the WMO (World Meteorological Organization). The idea is to improve the accuracy of weather prediction from 3 days to about 10-20 days. Starting in 1985, the GARP program could then be continued by a more extensive system of satellites: an efficient modern satellite network would consist of 4-6 large satellites in sun-synchronous and geostationary orbits as well as a number of instrumented aircraft, ships, balloons, and buoys. The data collected can then be coordinated, compared, analyzed, and distributed via satellite communications.

With this system and with the anticipated accuracy and reliability of measurement, a reasonable objective would be to achieve by the year 2000 a 1-year weather prediction for various regions and a 10-year weather prediction for the hemisphere. A program aimed at accomplishing and maintaining these long-range predictions would cost between 200 and 300 million dollars annually at current price levels. 16

Exploration of the Solar System

Currently unanswered questions in this area are shown in Table 2 (Topics 11 and 12). The main items are reconstructing the history of the solar system from its creation to its current state and obtaining data permitting deductions about the "earth phenomenon." One possible tool is the so-called comparative planetology: the planets Mercury, Venus, Mars, and Jupiter, which have been explored and photographed in recent years with the aid of space probes, exhibit atmospheres differing in density and chemical composition. Periods of rotation vary between 246 days for Venus and 10 hours for Jupiter, and cloud cover varies between 100% for Venus and 0% for Mercury and Mars. By comparing these planets and their characteristics, the effects of various parameters can be determined and applied to the earth.

We are still in the beginning stages of comparative planetology, however, since 95% of the mass of the planetary system is accounted for by Jupiter and the planets further out. Thus, future missions fall into two principal categories [5, 6]:

- 1) Detailed exploration of the inner planets
 - Pioneer Orbiter/Probe for Mars (1979/1980; [7]);
 - automatic return of surface rocks from Mars to earth [8], or
 - operation of an independent Mars surface vehicle (1981-1984);
 - Mercury orbiter (1983) and return of surface rocks from Mercury (after 1990);
 - Radar Orbiter for Venus for detailed recording of planetary surface features (after 1985) and optionally Venus Lander/return of material (after 1990);
- 2) Initial reconnaissance of the outer planets
 - Orbiter/Probe mission for Jupiter (1981);
 - probes to explore the atmosphere of Saturn and its ^{/7} moon Titan (1985), followed by a Titan Orbiter (after 1990);
 - Uranus probe with atmosphere entry vehicle (1988-1990);
 - Neptune probe (1996).

Depending on objectives and scientific necessity, further unmanned missions to the Moon (e.g. a lunar orbiter about 1980), and to asteroids and comets (after 1990) are conceivable. In order to actually prepare and carry out these missions, NASA has called for a major international scientific effort, a decade of joint solar system exploration. Whether there will be any response remains to be seen. The minimum outlays for the above program are about 200 million dollars in 1980, rising to almost 400 million dollars in 1988 (if the costly Mars return mission is implemented).

However, two facts, first that all previous planetary probe programs were afflicted in part by substantial cost overruns, and second that NASA's funds for (lunar and) planetary exploration (1975: 261.2 million dollars, 1976: 254.1 million dollars, 1977: 191.1 million dollars) are diminishing, imply

that prospects are not too bright for complete implementation of the rather modest program proposal for 1980-2000 described above. Hence, certain cutbacks or delays will be unavoidable.

Future Manned Space-Flight Programs Through 2000

It has already been mentioned that NASA will not carry out any manned missions (except for Space Shuttle/Spacelab flights) before 1980. After 1980, there will be increasing use of this modern transport system. As Table 3 shows, a total of 578 flights are scheduled for NASA's current Shuttle model through 1991. The European orbital laboratories Spacelab is to be carried on 226 of these missions (about 40%). On 197 missions, there will either by a upper rocket stage or a Space Tug to transport the payload to higher (e.g. geostationary) orbits.

For the coming decade, current planning has eliminated all previous ambitious plans for constructing a large space station /8 with a crew of dozens, first since many of the activities possible on board such a station can also be carried out in the Spacelab, and second because funds are not available for development of a space station at the same time as the Shuttle. It is not impossible, however, that the Shuttle can later be used to lift into earth orbit, assemble, and test components of manned space vehicles, e.g. for prolonged planetary missions. The same applies to small manned space stations, intended as assembly bases or factories. At any rate, just a few weeks ago NASA issued two industrial study contracts sponsoring research into the possibilities of a modular space station design assisted by the Space Shuttle. A decision on the actual construction of a freely orbiting station for 4-10 persons can hardly be expected before the beginning of the operational Shuttle phase, i.e. before 1981. Allowing 7 years for development and manufacture, we must assume that such a station would not be operational before 1990.

At present, no manned moon flights are scheduled in the US, unless a program of international cooperation is arranged, or unless analysis of lunar rocks or the data still arriving from the ALSEP lunar instruments from the Apollo program furnish totally surprising, perhaps dramatic results. The same applies to the long-discussed manned flight to Mars, which will certainly be replaced for the time being by an unmanned return mission. Aside from the great expense of such a manned project, it is still the uncertainty of the human factor, despite the 84-day flight of Skylab IV and the resulting biomedical knowledge, which places this mission last in the list of possible future US projects [9, 10].

The NASA "Outlook for Space" study lists two further highly futuristic projects: the construction of manned geostationary power-plant satellites (SSPS Project; [11]) and colonization of space [12, 13]. Both projects, although perhaps technically feasible, will have to stand up to hard questions regarding justification, safety, lifetime, profitability, and reliability, before they can be implemented. Peter Glaser, who first proposed the SSPS project 8 years ago, recently estimated -- highly optimistically -- the costs for developing a photovoltaic satellite power plant at just 20 billion dollars plus 24 billion /9 dollars to lift it into geostationary orbit, but the author of this article pointed out that about 1600 Space Shuttle flights would be required to orbit a 5000 MW output-power satellite [14]. These severe problems also apply to the "space colony" idea, since e.g. the settlement of about 100,000 persons proposed by Gerald K. O'Neill would be housed in a 500,000-ton donut (!). It is thus safe to assume that a very minimal priority will be accorded these two long-term projects. No matter which space projects are implemented in the next 2 or 3 decades, the decisive factors will no longer be just technological and financial ones -- as previously -- but instead ecological and political ones. The questions of how a given

project will benefit mankind on the earth and whether it will assist in solving terrestrial problems will definitely be the center of attention.

REFERENCES

1. Köhler, H. W., "Viking Program -- the landing on Mars," Umschau 75, No. 15 (1975).
2. v. Puttkamer, J., "Venus is unmasked," Umschau 76, No. 3 (1976).
3. NASA (ed.), "Outlook for Space," Report to the NASA Administrator by the Outlook for Space Study Group. NASA SP-386, January 1976.
4. NASA (ed.), "A forecast of space technology 1980-2000," NASA -- SP-387, January 1976.
5. AIAA (ed.), "Exploration of the solar system. An AIAA review," 28 February 1974, AIAA.
6. Schurmeier, H. M., "Planetary exploration: earth's new horizon," J. Spacecraft 12, No. 7 (July 1975).
7. Niehoff, H. C. and A. L. Friedlander, "Pioneers Mars 1979 mission options," J. Spacecraft 12, No. 8 (August 1975).
8. AIAA (ed.), "Mars sample return," Astronautics and Aeronautics, January 1975, AIAA.
9. v. Puttkamer, J., "Human beings are ready for space," Umschau 75, No. 24 (1975).
10. Winter, D. L., "Man in space: a time for perspective," Astronautics and aeronautics, October 1975.
11. Treinies, N., "Does a satellite power plant have a chance?" Umschau 75, No. 21 (1975).
12. v. Puttkamer, J., "After Apollo/Soyuz 'The future is space,'" Umschau 75, No. 16 (1975).
13. Köhler, H. W., "Space colonization -- sense or nonsense?" to appear (Naturwissenschaftliche Rundschau)
14. Köhler, H. W., "Solar energy, illusion or reality?" Technische Rundschau, No. 49, 26/11/1974, No. 51, 10/12/1974, and No. 53, 24/12/1974.

List of Diagrams:

Fig. 1:*The drawing illustrates the use of two navigation satellites which will regulate and monitor air traffic over the North Atlantic after 1979. This permits closer spacing between the individual airplanes, saving time and fuel. Drawing: COMSAT General Corporation/author's space-flight photo archive.

Fig. 2: Earth observation module in a small space station for monitoring earth's resources. Examples are mapping of fish movements, discovery of forest diseases, storm warnings, reports of fire outbreaks, monitoring of grain fields, and assistance in test drilling for oil. Drawing: NASA/author's space-flight photo archive.

Fig. 3: Mars surface vehicle proposed by German aeronautical and astronautical enterprise MBB as European participant in a later Viking mission. The Viking lander (background) releases the 180 kg 4-wheeled vehicle, which moves largely automatically on the ground, analyzes rock specimens, takes TV pictures, and transmits data to earth via the Viking Orbiter circling Mars. Drawing: MBB/author's space-flight photo archive.

Fig. 4: Upper stage of American Space shuttle with loading doors open. NASA will probably order three units, while the US Defense Department (DOD) has not committed itself yet. Photo: Rockwell International/author's space-flight photo archive.

Fig. 5: Female payload experts, part of the Shuttle/Spacelab program, are already preparing in the US for a possible mission. The picture shows Mrs. Carolyn Griner, who has already completed training in low-pressure chambers and water tanks with her two colleagues Dr. Mary Helen Johnston and Ann Whitaker. Photo: NASA-MSFC/author's space-flight photo archive.

Fig. 6: For future transport and communication tasks in space and for the assembly, evaluation, and operation of space vehicles and space stations, the LTV Aerospace Corporation in Dallas (Texas) has developed a space taxi. The photo shows a mark of the space taxi connected to a simulated job location in space by an anchor. Photo: LTV/author's space-flight photo archive.

*Translator's note: photos not available

Fig. 7: Design of a modular space station which can be placed in orbit using the Shuttle. The modules are about the size of a small bus, 4.3 m in diameter and 8.8 m long. This design, worked out by Rockwell International, provides four decks with living, working, and storage rooms. The wing-like structures are solar-cell supports for power generation. Some experimental modules are attached to the sides and bottom of the station. Drawing: Rockwell International/author's space-flight archive.

Fig. 8: Possible space-flight instruments of the future: from bottom to top: Space Shuttle/Spacelab, Space Tug, solar-electrical drive; large astronomical observatories, reusable satellites, orbital vehicles in synchronous orbits, manned Mars expedition; space station, Moon Base. Photo: NASA/author's space-flight photo archive.

(Fig. 8 may also serve as a title picture or may be published on the content's page of Umschau.)

TABLE I. NASA BUDGET 1975-1977 (IN THOUSANDS OF DOLLARS)

fiscal year	1975	1976	transition quarter 1977
research and development	2,323,563	2,677,380	700,600
maintenance and expansion of facilities	142,655	82,130	10,750
research and program management	764,704	795,498	220,795
total	3,230,922	3,555,008	932,145
			3,697,000

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

TABLE II. FUTURE SPACE PROJECTS -- 1980 THROUGH 2000

Earth-oriented Activities Aimed at Meeting Basic Human Needs

Category 1: Food and forestry

- Group 011: Prediction of global harvests
- Group 012: Prediction of water availability
- Group 013: Land use and assessment of environmental effects
- Group 014: Estimation of abundance of marine life
- Group 015: Discovery of forests of useful woods
- Group 016: Assessment of available grazing land

Category 2: Weather prediction and environmental protection

- Group 021: Long-term weather prediction
- Group 022: Support for experiments on modifying weather
- Group 023: Climate projection
- Group 024: Stratospheric changes and their effects
- Group 025: Registration of water quality
- Group 026: Global marine weather prediction

Category 3: Protection of life and property

- Group 031: Prediction of local weather and severe storms
- Group 033: Risk predictions from in-situ measurements
- Group 032: Recording pollution of the troposphere
- Group 034: Communication/navigation
- Group 035: Prediction of earthquakes
- Group 036: Control of harmful insects

Category 4: Energy production and mining

- Group 041: Solar power stations in space
- Group 042: Satellite energy transmission
- Group 043: Storage of dangerous wastes in space
- Group 044: Geological world atlas

Category 5: Information exchange

- Group 051: Communication in rural areas
- Group 052: Intercontinental communication
- Group 053: Personal communication

Category 6: Use of space for scientific and commercial purposes

- Group 061: Fundamental physics and chemistry
- Group 062: Mining and mineral processing
- Group 063: Commercial preparation of inorganic products
- Group 064: Research in the area of biological substances,
including applications-oriented experiments

- Group 065: Effects of gravitation on terrestrial life
- Group 067: Physiology and disease

Category 7: Scientific exploration of the earth

- Group 071: Earth's magnetic field
- Group 072: Dynamics of the earth's crust
- Group 073: Oceans depths and marine dynamics
- Group 074: Dynamics and energy exchange of lower atmosphere
- Group 075: Structure, chemistry, and dynamics of stratosphere and mesosphere
- Group 076: Boundary processes between ionosphere and magnetosphere

Extraterrestrial Activities Aimed at Meeting Human Desires for Knowledge

Category 8: Nature of the universe

- Group 081: How did the universe come into being?
- Group 082: How did the galaxies come into being and how did they develop?
- Group 083: What are quasars?
- Group 084: Will the universe expand perpetually?
- Group 085: What is gravity?

Category 9: Origin and end of matter

- Group 091: What are stellar explosions?
- Group 092: What are "black holes"?
- Group 093: Where and how were the elements formed?
- Group 094: What is the nature of cosmic rays?

Category 10: Life cycle of sun and stars

- Group 101: Composition and dynamics of interstellar matter
- Group 102: Why did interstellar dust condense into stars and planets and in what way did this take place?
- Group 103: What is the nature and cause of solar activity?
- Group 104: Corona and interplanetary plasma
- Group 105: What will the death of the sun be like?

Category 11: Origin of the solar system

- Group 111: What processes took place during the formation of the solar system?
- Group 112: How did the planets, their large moons, and their atmospheres originate?
- Group 113: How can dynamic processes in the atmosphere be measured quantitatively?
- Group 114: What is the origin and history of the magnetic fields?

Category 12: Origin and future of life

- Group 121: How did life originate on the earth?
- Group 122: Is there extraterrestrial life in the solar system?
- Group 123: What processes of organic chemistry are taking place in the universe?
- Group 124: Do other stars have planets?
- Group 125: Can we discover intelligent life beyond the earth?

TABLE III. NASA PROGRAM FOR THE SPACE SHUTTLE (AS OF DECEMBER 1975)

calendar year	79	80	81	82	83	84	85	86	87	88	89	90	91	total
development flights	3	3	-	-	-	-	-	-	-	-	-	-	-	6
operational flights	-	5	15	24	48	60	60	60	60	60	60	60	60	572
with Spacelab +)	-	2	6	12	17	19	21	21	24	24	24	27	29	226
with upper stage/space tug +)	-	3	8	12	15	17	22	21	21	20	19	20	19	197